Lunar EVA Dosimetry: Small Active Dosimetry System for Lunar Extravehicular Activity Missions: Spacesuit and Tool-Box Applications

Completed Technology Project (2007 - 2011)

Project Introduction

The objective of this project is the development of a compact active dosimetry system that can provide real-time radiation monitoring beyond low-Earth orbit (LEO). The dosimetry system would be capable of radiation monitoring during both ambient and solar particle event (SPE) conditions. It is designed to be responsive to the doses, dose rates, and radiation qualities (including secondary neutrons) expected in interplanetary space. This "mini-TEPC (tissue equivalent proportional counter) for deep space" builds on the extensive (and successful) performance history of the much larger tissue-equivalent proportional counters that have been on the Space Shuttle and on the International Space Station (ISS) for two decades, but which are much too large and power intensive to be used beyond LEO. The key innovations of our mini-TEPC are its compact size, low power, and no saturation during large SPEs, while at the same time maintaining the TEPC advantages of tissue equivalence and lineal-energy response. These advances in miniaturization and power are made possible in part by our incorporation of an innovative variance-covariance data collection and processing approach. As astronauts travel beyond LEO and explore asteroids, the Moon, and Mars, there will be a critical need for compact active personal radiation monitoring. Of particular concern is the need for real-time dose-rate measurements during SPEs so that astronauts can seek prompt shelter. SPEs may occur unexpectedly and with highly variable dose rate and can potentially result in high radiation doses to astronauts. The dynamic radiation environment in space requires the development of suitable detection systems that can detect a broad range of dose rates as well as a complex mixture of radiation types.

This project is a joint effort between NASA Ames Research Center (ARC), Colorado State University (CSU), and Texas A&M University (TAMU). Importantly, two separate National Space Biomedical Research Institute (NSBRI) grants support this effort (Radiation Effects-RE01301--Principal Investigator Borak and RE01302--Principal Investigator Straume) and reports from both of these grants should be viewed together to appreciate the total effort. CSU designs and fabricates the TEPC sensors, TAMU designs and builds the pre-amplifier with charge integrator, and ARC designs and builds the miniaturized electronics package with bias voltage power supply and microprocessor and programs the microprocessor to calculate dose-mean lineal energy (yD), quality factor, dose, and dose-equivalent.

In this project, hardware specifications required by NASA for this technology have either been met or exceeded. We have shown that the tissue equivalent sensor has omni-directional response and can detect radiation with linear energy transfer (LET) between 0.2 and 300 keV/µm. We have also shown that the TEPC monitor can detect maximum credible SPEs without saturation, has good precision and time resolution, consumes only 0.75 W of power, and has a mass of only about 250 g. Hence, it is adaptable to either a real-time personal dosimeter or an area monitor. Additional efforts are, however, required to fine-tune software related to yD calculations, which effect precision of the

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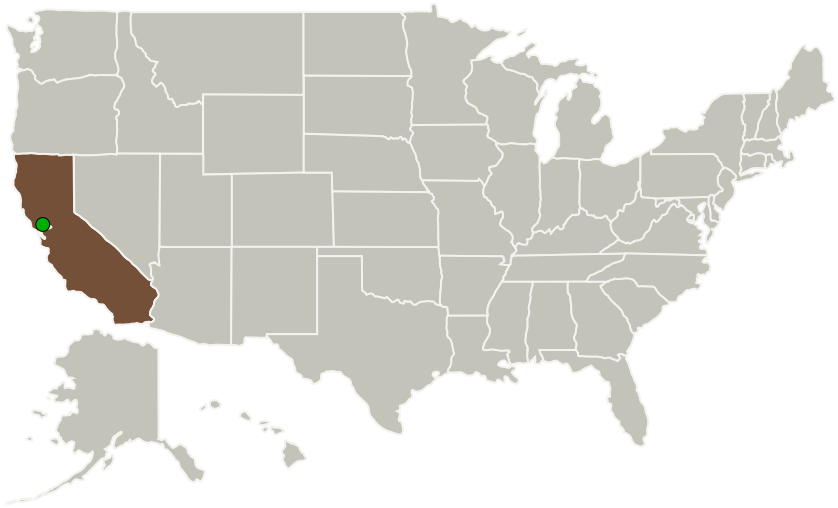
dose-equivalent rate measurements, but not absorbed dose rate measurements of greatest importance during SPEs. Also, there is a need for additional testing to better define the lower limit of detection, which is important during ambient (non-SPE) conditions. It is recommended that follow-on efforts should be undertaken by NASA to advance this proof-of-principle prototype with the aim of answering the fundamental question: Should this mini-TEPC technology approach be part of NASA's suite of detector systems for deep space missions? Additional evaluations of this technology should be performed to obtain a clear answer to this question.

Anticipated Benefits

The compact real-time radiation monitoring capability developed in this project may be useful in homeland security and Department of Defense (DOD) applications, where first responders would require small personal dosimeters capable of detecting real-time mixed gamma and neutron radiations. It may also be applied in high-energy research or medical accelerator facilities where mixed radiations are produced.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Organization:

National Space Biomedical Research Institute (NSBRI)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

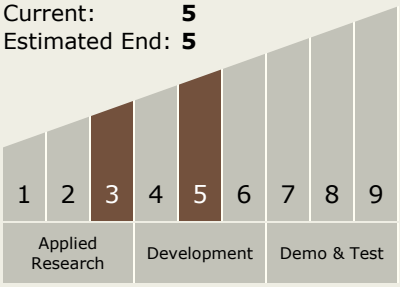
Tore Straume

Co-Investigators:

Leslie Braby
Terry C Lusby

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



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Organizations Performing Work	Role	Type	Location
National Space Biomedical Research Institute(NSBRI)	Lead Organization	Industry	Houston, Texas
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Texas A&M Engineering Experiment Station(TEES)	Supporting Organization	Academia	College Station, Texas

Primary U.S. Work Locations
California

Project Transitions

November 2007: Project Start

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.5 Radiation
    - TX06.5.5 Monitoring Technology

Target Destinations

The Moon, Mars

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October 2011: Closed out

Closeout Summary: During year 4 (final year for this grant) we developed and fabricated final components, assembled, a nd tested. The tissue-equivalent sensor was redesigned to improve mechanical reliability. The original design used a single crimp fastener to tension the anode wire and make the electrical connection between the anode and the charge integrator i nput. This crimp connector could slip in the high molecular weight anode insulator when it was being connected or disconne cted from the integrator, resulting in a loose or broken anode wire. This problem was eliminated by replacing the aluminum flange with one machined from stainless steel. The completed detector and charge integrator assembly was tested using bo th gamma-ray and neutron sources, with data acquisition accomplished using a commercial data logger and later with the miniaturized electronics package. The relative variance minus the relative covariance (v-c) was then calculated. The slope o f the change in output voltage was determined and the calibration factor for the detector/charge integrator was determine d. The calibration factor was then used to convert v-c, which is calculated in volts, to dose mean single event specific energ y in Gy, and the geometry and mass of gas in the detector was used to convert single event specific energy to lineal energy in keV/µm. This approach produced results consistent with published values of the dose mean lineal energy for the radiatio n sources measured. The final electronic schematics and board fabrication files were developed and prototype fabricated for testing with radiation sources. The design consisted of a main board, daughter board, and sensor interface board. These bo ards fit into a compact aluminum enclosure. The prototype can be programmed in ANSI C, operate from battery power, co mmunicate through USB through a simple terminal, and connect to a standard evaluation board to measure apparent diffusi on coefficient (ADC) performance. Each unit has auxiliary user pins for connection of additional inputs or outputs. C-progra mming was developed for control and for processing the algorithm based on the data conditioning and results of the Excel a nalyses. A custom LabView control interface was developed and is capable of graphing dose rate and dose equivalent rate a long with providing total integrated dose and dose equivalent. In conclusion, hardware requirements specified by NASA for t his technology have either been met or exceeded: tissue equivalent sensor, omni-directional response, LET response betwe en 0.2 and 300 keV/µm, detects maximum credible SPE without saturation, measures dose rate to required level of precisio n and time resolution, very low power consumption (about 0.75 W), low mass (about 250 g), and adaptable to either a pers onal dosimeter or area monitor. Additional software work is required to improve yD calculations, and more tests are require d to better define lower limit of detection, important for ambient dose-equivalent rates in space.

Stories

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/53917)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/53919)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/53913)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/53911)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/53915)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/53921)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/53923)

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Project Website:

https://taskbook.nasaprs.com